AD-A147 538 INTERACTIVE COLOR-GRAPHICS INTERFACE FOR ENERGY MONITORING AND CONTROL SYSTEMS(U) NAVAL CIVIL ENGINEERING LAB PORT HUENEME CA K J CANFIELD MAY 84 1/1

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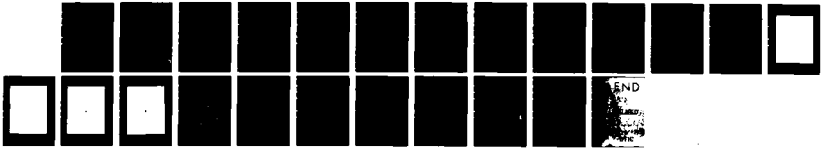

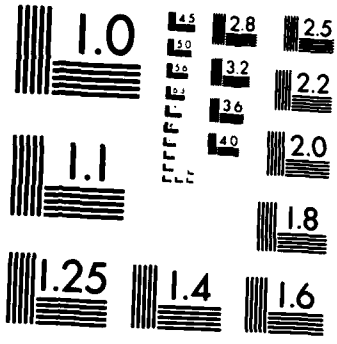

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AUTHOR: Karlin J. Canfield

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NAVAL CIVIL ENGINEERING LABORATORY
PORT HUENEME, CALIFORNIA 93043

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METRIC CONVERSION FACTORS

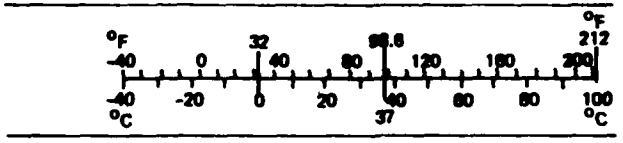
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2,000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1,000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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20 ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

Energy monitoring and control systems (EMCS) are computerized systems that control and monitor energy consuming and producing equipment at facilities. The larger systems have been installed with color-graphics cathode ray tube operator consoles to provide better information to the personnel operating these systems. This report summarizes the work done on defining an adequate operator console and recommends changes to the existing EMCS Guide Specifications.

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Energy monitoring and control systems (EMCS) are computerized systems that control and monitor energy consuming and producing equipment at facilities. The larger systems have been installed with color-graphics cathode ray tube operator consoles to provide better information to the personnel operating these systems. This report summarizes the work done on defining an adequate operator console and recommends changes to the existing EMCS Guide Specifications.

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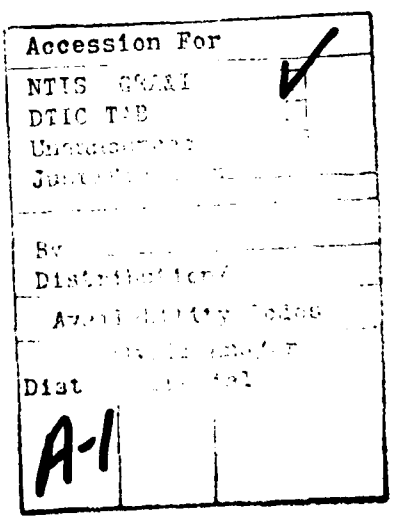

INTRODUCTION

The man/machine interface (MMI) on a computerized system heavily influences the acceptance and use of that system. Energy monitoring and control systems (EMCS) are computerized systems that require a good MMI that is easy to learn and use but still has the necessary functions to effectively utilize the system. The EMCS that are procured using the medium and large EMCS Guide Specifications call for a color-graphics terminal to be used as the primary operator interface to the EMCS.

A research and development (R&D) effort initiated in FY80 has investigated interactive color graphics for EMCS applications and has developed a prototype EMCS MMI device that incorporates the features deemed desirable. This report summarizes the findings of the EMCS MMI effort and provides a proposed change to the large and medium EMCS Guide Specifications.

DISCUSSION

An EMCS can be described as a system that automatically takes care of routine operation of equipment and provides centralized reporting and override capabilities. Equipment controlled by an EMCS would be heating, ventilating, and air conditioning (HVAC) equipment, air compressors, and small package boiler units. The EMCS would obtain raw information (data) from sensors associated with the equipment and massage the data into useful information. The information obtained from the sensors plus additional information available to the EMCS would be used to control the equipment. The information would also be available to the operator in the form of reports or in response to operator commands for specific information.

The EMCS that were installed prior to the development of the EMCS Guide Specifications usually had a monochrome (one-color) cathode ray tube (CRT) terminal as the operator interface. A slide projector/screen was occasionally incorporated into the system to provide diagrams of the equipment and buildings under control. The system would display the slide on operator command or automatically upon certain conditions.

In mid-1970 tremendous strides were made in developing color-graphics terminals at a reasonable price. These units were specified in the large and medium EMCS Guide Specifications. Most of the manufacturers used a fairly low resolution device that provided tolerable graphics. The typical resolution was 160 by 192 pixels. (A pixel, or pixel element, is the smallest space that can be controlled on the screen). This low-resolution device made circles and diagonal lines appear rather strange, but identifiable.

The first systems obtained under the EMCS Guide Specifications did provide graphics capabilities and assisted the operator in understanding what was happening. The operator used the typewriter-like keyboard, special function keys, or a light pen to interact with the system.

All of these systems lacked the degree of "friendliness" that was desired for use in government installations. An investigation was initiated in FY80 that resulted in Contract Report CR 81.013, "A Man-Machine Interface for Energy Monitoring and Control Systems."* This report determined that there were three levels of operator interaction with an EMCS: level 1 (lowest), the actual operator of the EMCS; level 2, the supervisor; and level 3, the EMCS software maintenance personnel. The EMCS operator is the person most involved with the day-to-day operation of the system, and the "operator" console should be designed with this individual in mind.

EMCS operator qualifications are typically a high school education and field experience or technical training in HVAC or a related field, with no requirement for typing skills. Technical skills in HVAC instead of typing skills are required because the operator is controlling HVAC equipment and the computerized EMCS should be as "transparent" or non-obtrusive as possible. This means that when an EMCS operator is turning on a piece of equipment or modifying equipment operating schedules or characteristics, the operator should feel in direct control of the equipment, not a computer that then decides to operate the equipment. People with other skills (secretarial, computer programmers, etc.) have made good operators, but people with HVAC background are predominant.

Since typical EMCS operators have HVAC background and are not typists, it makes sense to limit the amount of typing that the operator has to do. There are many different techniques that allow an operator to rapidly perform desired tasks with a minimum of typing; a few of these techniques that can be used, either by themselves or in combination, are: menu-penetration, light pen, track ball, joy stick, optical mouse, touch screen, and voice recognition.

An operator should be able to perform the following tasks identified in the EMCS Guide specifications:

- Request a display of any digital or analog point or any logical group of related points in the system
- Start up and shut down any selected systems or devices
- Initiate reports
- Request graphics displays
- Modify time and event scheduling
- Modify analog limits

*Wise, B.B. (1981). A man-machine interface for energy monitoring and control systems, Civil Engineering Laboratory, Contract Report CR 81.013. Atlanta, Ga., Georgia Institute of Technology, Electronics and Computer Systems Lab, Engineering Experiment Station, Jun 1981. (Contract no. F33615-77-C-2204)

- Adjust set points of selected controllers
- Select manual or automatic control modes
- Enable and disable individual points
- Enable and disable individual field interface devices (FIDs)
- Enable and disable individual multiplexes/intelligent multiplexes (MUX/IMUX) panels

Every point (temperature sensor, control relay, etc.) that is connected to an EMCS has a unique description. In most of the systems, the operator has to type in the complete or abbreviated description of the point in a very precise format to obtain information or to exercise control. The EMCS is very fussy about correct spelling, spaces, and punctuation marks. This has led to considerable operator frustration. Other negative factors have also surfaced:

1. Some EMCS do not provide "feedback" in the optimum 3- to 5-second response time. This means that the operator has no feeling whether the system has accepted the command or if it is proceeding normally.

2. The operator never feels that the set of commands is "closing." Studies have shown that most people like to have short sequences of commands that terminate so they have a feeling of accomplishment. This also means that if a mistake is made, a long sequence of commands does not have to be redone.

3. The operator does not feel like he is in control of the system. People like to enter a set of commands, submit them, and then have the computer parrot the commands back and ask for permission to execute the commands.

The MMI concept developed in CR 81.013* seems to overcome the majority of these problems. The primary concept is to make the MMI appear to the operator as a remote readout/controller of equipment and make the EMCS as "transparent" as possible. Color-graphics displays that the operator can interact with appear to be the best answer. Recommendations for developing an interactive graphics system can be summarized in two statements:

1. Provide a graphics representation familiar to the operator.

2. Provide standard operations.

*See footnote on page 2.

The MMI concept proposed in CR 81.013* was tested by developing a prototype EMCS MMI device, which has been extended to be an EMCS operator training device. The prototype EMCS MMI device was developed using equipment that would provide a good interface for a typical EMCS operator. A 512- by 512-pixel-resolution color-graphics device was selected to provide the capability of representing circles and diagonal lines that looked like circles and diagonal lines. Figures 1-4 show the difference between a display using 160- by 192-pixel resolution and one using 512- by 512-pixel resolution (a notable difference). Higher resolution devices are available, but ones that have at least 480- by 360-pixel resolution are adequate to present displays that look like typical drawings familiar to the operators.

The most natural operator method of interacting with a diagram on a color-graphics terminal is pointing. Equipment supporting this interface method has already been identified, and the strengths and weaknesses have been summed up in CR 81.013.* The interface selected as the best choice for the prototype MMI device was an infrared touch screen. During the development of the prototype, it was determined that the minimum size area that people could accurately touch was about 1/2 by 1/2 inch and larger. Anything smaller than this resulted in too many errors.

Another determination was on the use of color. EMCS color-graphics operator consoles have a minimum of eight colors available, and very colorful displays have been generated. In fact, they are so colorful it is hard to obtain any information from the display. The prototype MMI overcomes this problem by using color sparingly and consistently. The schematics of equipment are done in dark blue lines. EMCS points are outlined in (light blue). EMCS points and equipment that are active are filled with green, while inactive points and nonoperating equipment are blank. When a point is selected, a yellow outline replaces the existing cyan outline to identify to the operator the selected point or equipment. When a point is in alarm, the outline blinks. A typical screen that an operator might see is shown in Figure 5 (from CR 83.021**).

The prototype MMI has been successfully demonstrated and meets the objective of developing an improved EMCS MMI. The unit has been successfully used in the NCEL developed EMCS operator training course to give hands-on training. All comments about the device have been very favorable. The operation of the device has been very easy to explain, and the class members have been comfortable interacting with the system in about 30 minutes. The equipment has been fairly reliable, but is cumbersome for transporting. Better units are now on the market.

---

*See footnote on page 2.

**Cornelius, C., Wise, B., and Bruning, S. (1983). EMCS operator training manual, Naval Civil Engineering Laboratory, Contract Report CR 83.021. Atlanta, Ga., Newcomb & Boyd, Consulting Engineers, Apr 1983. (Contract No. N62474-81-C-9405, ADA128087)

CONCLUSIONS

The prototype EMCS MMI has successfully demonstrated a friendly operator interface. The salient features of a good EMCS operator interface, as determined from this project, are:

1. The MMI should have a 19-inch color CRT with a resolution of at least 480 by 360 pixels.

2. Color should be used sparingly and consistently in the displays.

3. Operator interaction should consist of short sequences of commands with an operator confirm/cancel action at the end.

4. The commands should be the same for similar situations.

5. Operator input enhancement devices should be used to elimina the majority of the typing.

An EMCS that incorporates these salient features in the MMI would be easy to learn and to use.

RECOMMENDATIONS

The EMCS Guide Specifications using color-graphics CRT display units should be changed to incorporate a better MMI. The Appendix details a proposed modification to the EMCS Guide Specifications to obtain a better MMI while still allowing EMCS manufacturers flexibility in implementing their systems.

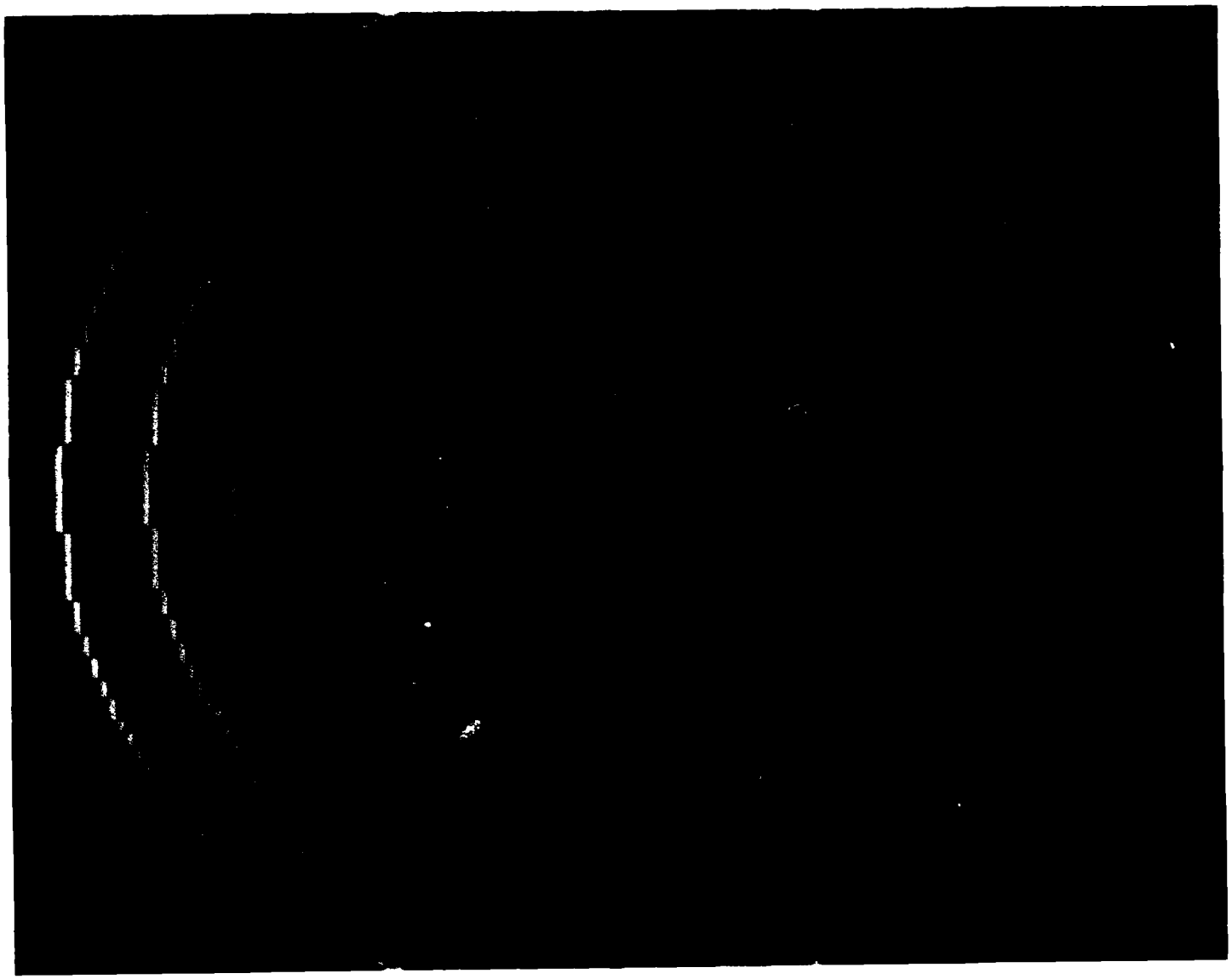

Figure 1. Low resolution CRT circles.

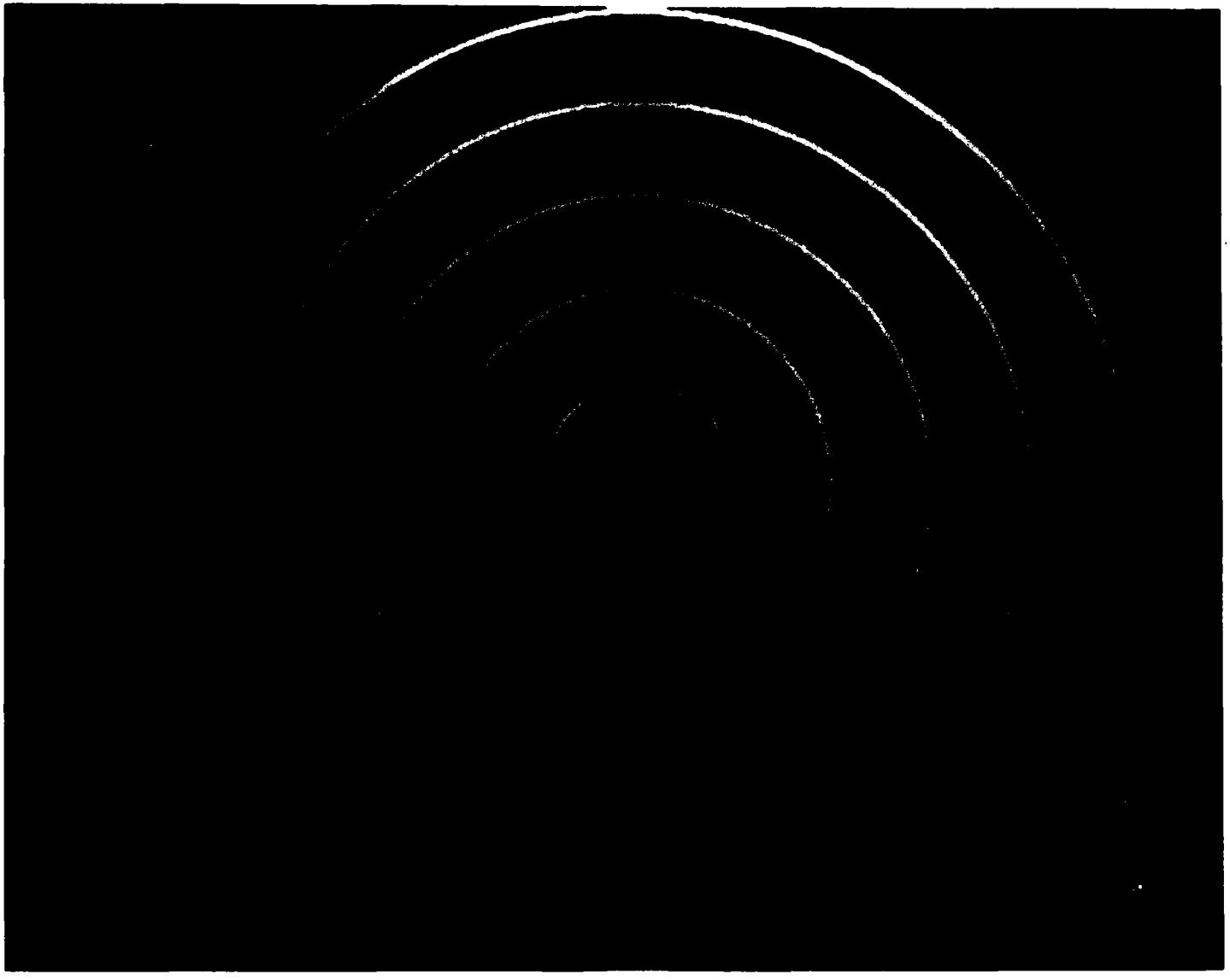

Figure 2. Medium resolution CRT circles.

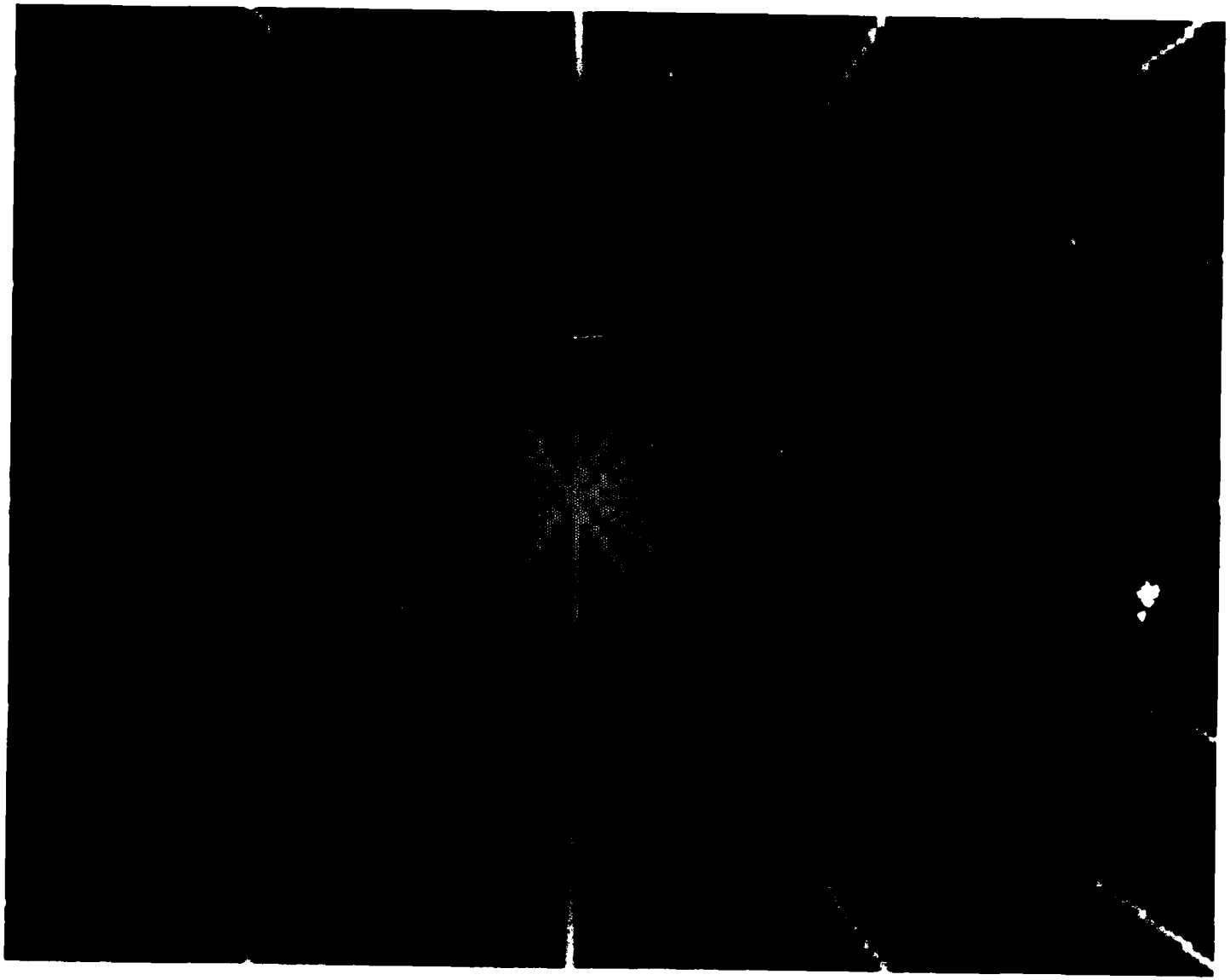

Figure 3. Low resolution CRT lines.

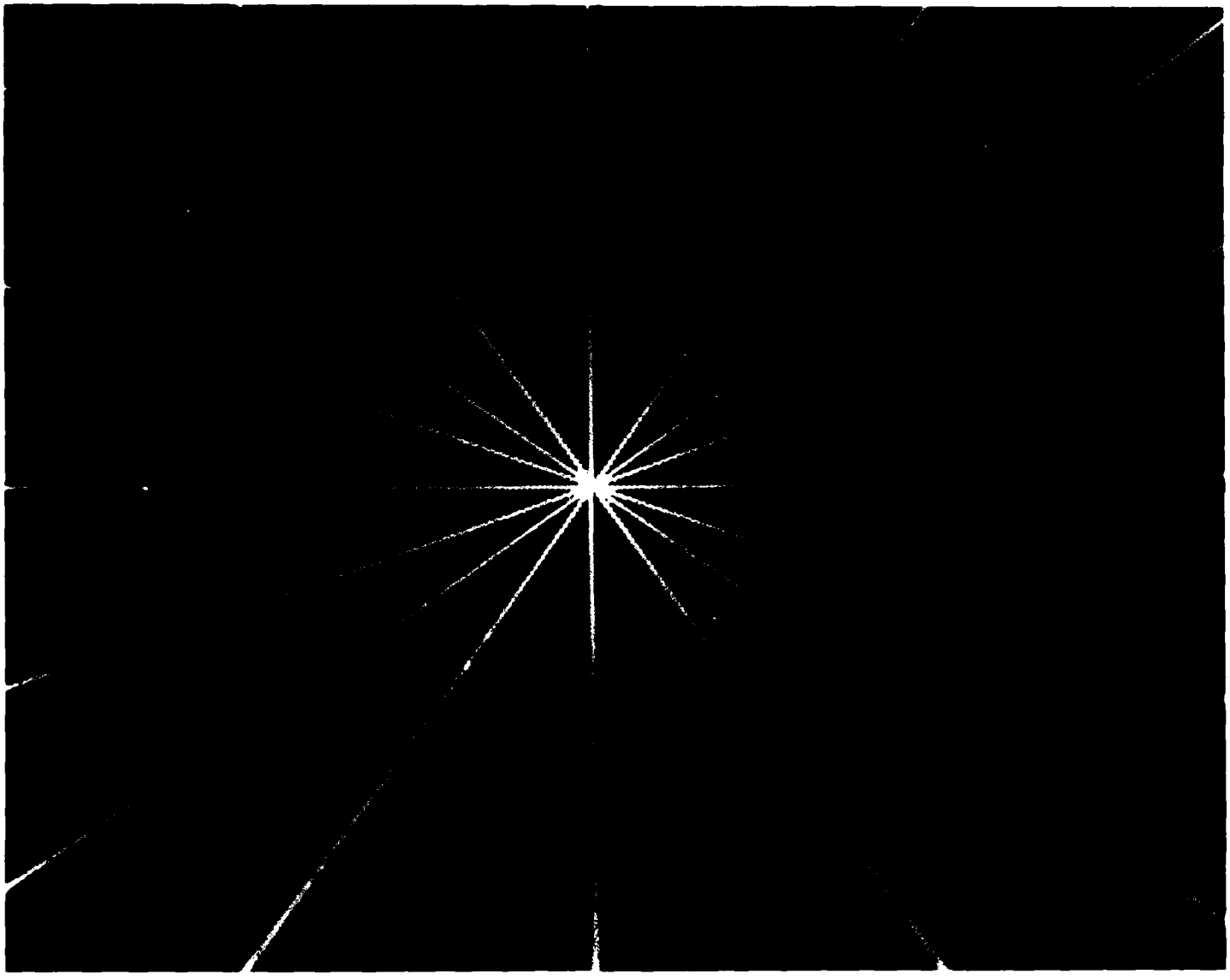

Figure 4. Medium resolution CRT lines.

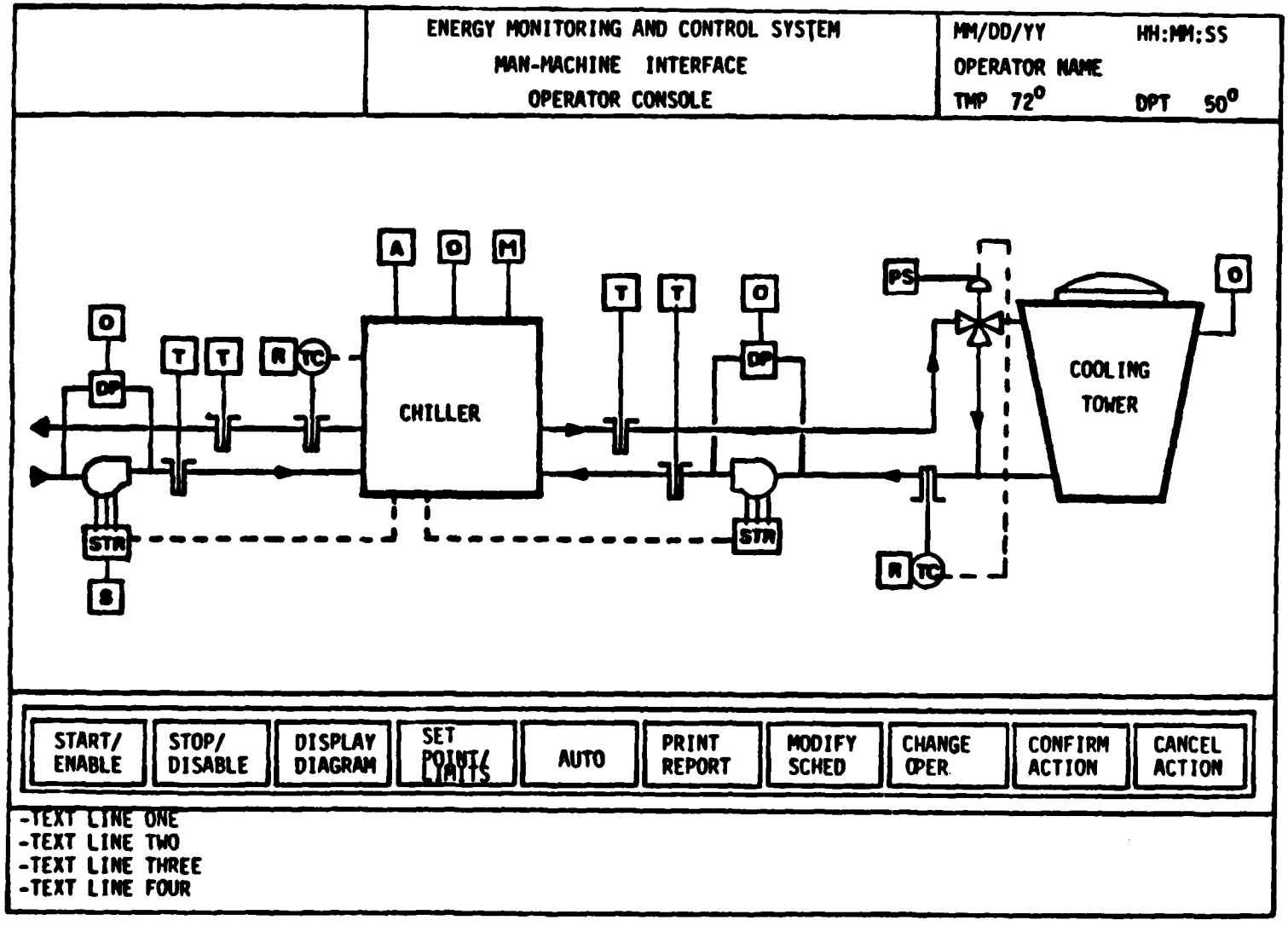

Figure 5. Typical color-graphics screen (from CR 83.021; see footnote on page 4).

Appendix

PROPOSED CHANGES TO THE EMCS GUIDE SPECIFICATIONS

The following changes are proposed for the EMCS Guide Specifications containing color-graphics CRT display units.*

Change the paragraph dealing with the color graphics CRT display unit to read:

> Color-Graphics CRT Display Unit: The color-graphics display shall consist of a microprocessor-based, 19-inch (nominal) color CRT. The unit shall have refresh (RAM) memory with a screen refresh rate of at least 60 times per second, noninterlaced. The CRT shall have a minimum screen display of 3,200 characters (40 lines with 80 characters each). The screen display shall have a resolution of 480 by 360 pixels.

Change the paragraph dealing with the command keys to read:

> Operator Input Enhancement: Provide special function keys, light pen, track ball, joy stick, optical mouse, or touch screen devices for frequently used operator commands.

Change the paragraph dealing with command line mnemonic interpretation (CLMI) to read:

> COMMAND SOFTWARE:
>
> Basic Operator Commands: Provide menu-driven, English language basic operator commands with the system for defining and selecting points, parameters, report generation, and all functions associated with day-to-day operation of the EMCS. The basic operator commands shall be useable from the operator console, system terminals, keyboard printer, or remote terminal systems with individual operator password protection. The operator console shall be enhanced with special function keys, light pen, track ball, joy stick, optical mouse, or touch screen device for frequently used operator commands. Operator console enhancement shall include the following commands: Start/Enable, Stop/Disable, Display Diagram, Set Point/Limit, Auto/Manual, Print/Report, Modify Schedule, Change Operator, Confirm Action, and Cancel Action.

*The change dealing with the command keys and the command line mnemonic interpretation (CLMI) can be made immediately. The other changes should be announced to the EMCS manufacturers about 2 years before they would become effective.

Change the graphics display implementation paragraph to read:

Graphic Display Implementation: Provide graphics displays with the latest available process data integrated with the display. When the graphics display is active on the operator console, the data associated with that display shall be updated whenever the data base is updated. Use the schematics shown as a guide for the graphics displays. Incorporate each system schematic as a separate graphics display keyed to the building in which it is installed. Include graphics of all systems noted in the input-output summary tables and shown elsewhere. The non-EMCS equipment and building schematics shall be outlined in dark blue. EMCS equipment and points shall be outlined in cyan. All equipment and points that are enabled or started shall be filled in with green. All equipment and points that are disabled or stopped shall be blank. Equipment and points that are in alarm shall have its outline blinking until the alarm condition is corrected.* Colors shall be uniform on all displays. Alarm messages shall be displayed to the operator in white with a flashing red background, identifying the alarm and associated graphics display.

*Points and equipment selected by the operator shall be outlined in yellow until operator action is completed and returned to cyan or dark blue outline.

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4 Utilities (including power conditioning)
5 Explosives safety
6 Construction equipment and machinery
7 Fire prevention and control
8 Antenna technology
9 Structural analysis and design (including numerical and computer techniques)
10 Protective construction (including hardened shelters, shock and vibration studies)
11 Soil/rock mechanics
13 BEQ
14 Airfields and pavements
15 **ADVANCED BASE AND AMPHIBIOUS FACILITIES**
16 Base facilities (including shelters, power generation, water supplies)
17 Expedient roads/airfields/bridges
18 Amphibious operations (including breakwaters, wave forces)
19 Over-the-Beach operations (including containerization, materiel transfer, lighterage and cranes)
20 POL storage, transfer and distribution
24 **POLAR ENGINEERING**
24 Same as Advanced Base and Amphibious Facilities, except limited to cold-region environments
28 **ENERGY/POWER GENERATION**
29 Thermal conservation (thermal engineering of buildings, HVAC systems, energy loss measurement, power generation)
30 Controls and electrical conservation (electrical systems, energy monitoring and control systems)
31 Fuel flexibility (liquid fuels, coal utilization, energy from solid waste)
32 Alternate energy source (geothermal power, photovoltaic power systems, solar systems, wind systems, energy storage systems)
33 Site data and systems integration (energy resource data, energy consumption data, integrating energy systems)
34 **ENVIRONMENTAL PROTECTION**
35 Solid waste management
36 Hazardous/toxic materials management
37 Wastewater management and sanitary engineering
38 Oil pollution removal and recovery
39 Air pollution
40 Noise abatement
44 **OCEAN ENGINEERING**
45 Seafloor soils and foundations
46 Seafloor construction systems and operations (including diver and manipulator tools)
47 Undersea structures and materials
48 Anchors and moorings
49 Undersea power systems, electromechanical cables, and connectors
50 Pressure vessel facilities
51 Physical environment (including site surveying)
52 Ocean-based concrete structures
53 Hyperbaric chambers
54 Undersea cable dynamics

TYPES OF DOCUMENTS

85 Techdata Sheets
86 Technical Reports and Technical Notes
82 NCEL Guide & Updates
83 Table of Contents & Index to TDS
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